SALT CONCENTRATIONS IN GROUND WATERS BENEATH RHIZOPHORA MANGLE AND AVICENNIA GERMINANS

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The purpose of this investigation was to determine whether salinity of ground water beneath *Rhizophora mangle* L., (red mangrove), and *Avicennia germinans* (L.) L., (black mangrove), was correlated with the distribution of these species. It was expected that there might be a mixture of fresh ground water and tidal salt water and that the levels of resulting salinity might be a deciding factor in their distribution. Moog (1963) stated on the basis of his preliminary studies that *A. germinans* was regulated by this salt variation. He found that in salt pools where there was a high concentration of salt (higher than sea water) the growth of *A. germinans* was dwarfed and the trees grew poorly, growing only approximately 2 cm. per year. Individuals of the marsh area, he reported, thrived, growing 8 to 30 cm. per year. Moog ascribed this difference to the fact that they were in contact with fresh water daily at high tide when the underlying fresh-water table was raised due to tidal pressure.

The method of testing was to drill a hole near the base of the individual of a particular species with a three-foot-long hand auger. Next a small hand pump with a two-foot-long hose was put into the hole and a sample of water was taken. This sample was kept in a sealed glass test tube and later that day tested for conductivity with a Beckman conductivity bridge, Model RC-19, which gives its results

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in micromhos per centimenter (μmho/cm). Conductivity is the reciprocal of resistivity and is expressed in mho/cm (mho = 1/ohm, μmho = $1/10^6$ ohms). This technique does not indicate salinity directly, but does give conductivities which can be compared to the conductivities of sea water and of fresh water. A higher conductivity would mean higher concentration of salts, of which, in sea water, sodium chloride would be predominant.

The samples were taken during January, 1971, on five cays (Coakley, Bowe, Ben Rolle, Hummingbird and Culmer's) of the Jewfish Chain, which runs westward at 23.5°N from George Town, Great Exuma, in the Bahamas. Hummingbird Cay and the other islands are discussed further in a study now in preparation (Nickerson et al, 1973).

Several samples of open sea water were tested; they displayed a conductivity of 62.7k umho/cm. In contrast, fresh water from a well on Hummingbird Cay, site of the Hummingbird Cay Foundation's Biological Laboratory, displayed a conductivity of 1.03 μmho/cm. These values mean resistances of approximately 16 ohms for 1 cm of seawater and 1000 ohms for 1 cm of fresh water. They also mean for seawater, about 37,000 ppm NaCl at 25°C. and for the well sample, about 450 ppm NaCl at 25°C.

Very few *Laguncularia racemosa* (L.) Gaertn. (white mangrove) were tested because the soil was usually too dry beneath them to obtain a sample. The one that could be tested had a conductivity of 62.9k. This species is not dealt with further in this study.

Fifteen samples were taken from areas in which *Rhizophora mangle* grew exclusively. The average conductivity was 63.2k, approximately that of sea water.

Sixteen samples were taken from areas where *Avicennia germinans* occurred exclusively. They had a much higher average conductivity (72.1k), with the highest individual sample at 88.8k. In areas where both *A. germinans* and *R. mangle* were found in approximately the same numbers, the average of eight samples was 67.7k, approximately midway between the other two averages. These data are summarized in Table I.

The areas where *A. germinans* was found were usually depressions, often partly filled with sand, where the salt ocean water flowed in at high tide and stayed even after the tide went out. This condition would form a salt pool, which the results show, because the water apparently evaporated and left the salt behind. Our results were quite consistent. There were only two black mangrove areas with salinity equal to sea water, and we were unable to determine the shape of the underlying rocks in these areas with any degree of reliability. These results are interpreted to mean that *A. germinans* grows where it does because of a higher concentration of salt in the ambient water than that found in sea water. Whether *A. germinans* needs the higher concentration of salt or whether it just tolerates it is another question to which these data do not speak.

Moog (1963) noted that the osmotic pressure in *A. germinans* is 21.5 atm. and in *R. mangle* it is 27 atm. The energy required to remove only water from sea water should be less with increased internal osmotic pressure and thus it would presumably be easier for *R. mangle* to obtain fresh water from sea water. *A. germinans,* however, secretes salt (NaCl) in large quantities on its leaves: hence it must absorb salt water from its environment. It is also possible that *A. germinans* grows in salt pools because of the lack of competition from other plants. There are solid stands of *A. germinans* in inland salt-pool areas on several islands of the Jewfish chain.

Rhizophora mangle is always found in either open sea water or in tidal flat areas that are covered with large quantities of new sea water each day at high tide. The conductivity of water samples obtained beneath these *R. mangle* colonies at the time of testing was always close to that of sea water. Davis (1943) reported that *R. mangle* will live at least six years in a greenhouse with only fresh water, which indicates that it can perhaps adapt to fresh water. Against this evidence is a color infra-red aerial photograph of the

Marco Island area of western Florida, which shows a progressive color change, interpreted as slow dying of mangrove swamps from which the sea has been excluded by diking (Nickerson, 1971, Plate 4.)

Our evidence indicates that *R. mangle* survives only in areas where salinity approximates that of sea water, and where sea water is free to exchange with the ocean at each tide. It indicates that *A. germinans* thrives in areas where salinities consistently exceed that of sea water, and where there is not a free exchange of root-bathing waters with the ocean at each tide.

TABLE I
TABLE OF CONDUCTIVITIES FOR EACH WATER SAMPLE

(in thousands of μmhos/cm)

Rhizophora	*Avicennia*	*Rhizophora & Avicennia*	*Laguncularia*
61.7	82.1	62.8	62.9
62.4	88.8	69.9	
57.7	71.5	68.8	
64.6	80.5	72.3	
65.6	70.2	72.3	
62.6	72.3	63.1	
63.5	70.2	67.3	
55.5	65.5	64.9	
55.7	63.9	av. 67.7	
58.7	69.2		
65.0	71.9		
69.9	78.6		
65.5	68.3		
70.5	74.4		
69.2	65.2		
av. 63.2	61.0		
	av. 72.1		

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VARIATION OF SEED SIZE IN ATRIPLEX PATULA VAR. HASTATA (L.) Gray

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Ungar (Rhodora 73:548-551, 1971) demonstrated seed dimorphism in *Atriplex patula* var. *hastata* (L.) Gray collected from saline marshes surrounding Lincoln, Nebraska. One kind of seed is small (1.0-1.7 mm) having a hard black testa and the other is usually larger (1.3-2.6 mm) having a soft yellowish-brown testa. Ungar (1971) shows a bimodal distribution of this condition. He has informed me that individuals of *A. patula* var. *hastata* do not yield equal numbers of each seed type, but he did not know the relative yields of each type.

In order to investigate this matter further, six lots of four to fourteen individuals each of *A. patula* var. *hastata* were harvested from an Alexander Township, Athens County, Ohio salt pan during October, 1971. Seeds were separated from fruits by chaffing. Small black seeds and larger brown seeds from each lot were counted (Table 1) and placed in separate envelopes. Samples from each category in each lot were placed on a piece of filter paper. With a dissecting